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PATENT APPLICATION OF

Harvey A. Restaino,
Timothy Paul Demel,
and
Christian Pimentel

ENTITLED

REPLACEABLE CLAMP FOR ELECTRONIC BATTERY TESTER

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REPLACEABLE CLAMP FOR ELECTRONIC BATTERY TESTER

BACKGROUND OF THE INVENTION

The present invention relates to electronic battery testers and chargers of the type used to electrically test and charge storage batteries. More specifically, the present invention relates to clamps which are used to electrically couple such electronic battery testers and chargers to terminals of storage batteries.

Storage batteries are used in many applications as sources of power. For example, storage batteries are used in automotive vehicles, both electrical vehicles and vehicles with internal combustion engines, as well as power supplies such as backup power systems. It is often desirable to measure the condition of such storage batteries. For example, it can be useful to determine the amount of charge a storage battery can hold (i.e. the capacity of the battery) or the state of health of a storage battery.

A number of battery testing techniques are known in the art. These techniques include measuring the specific gravity of acid contained in a storage battery. Measuring a battery voltage and performing a load test on a battery in which a large load is placed on the battery and the response observed. More recently, a technique has been pioneered by Dr. Keith S. Champlin and Midtronics, Inc. of Willowbrook, Illinois for testing storage batteries by measuring

the conductance of the batteries. This technique is described in a number of United States patents, for example, U.S. Patent No. 3,873,911, issued March 25, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Patent No. 3,909,708, issued September 30, 1975, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Patent No. 4,816,768, issued March 28, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE; U.S. Patent No. 4,825,170, issued April 25, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING; U.S. Patent No. 4,881,038, issued November 14, 1989, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH AUTOMATIC VOLTAGE SCALING TO DETERMINE DYNAMIC CONDUCTANCE; U.S. Patent No. 4,912,416, issued March 27, 1990, to Champlin, entitled ELECTRONIC BATTERY TESTING DEVICE WITH STATE-OF-CHARGE COMPENSATION; U.S. Patent No. 5,140,269, issued August 18, 1992, to Champlin, entitled ELECTRONIC TESTER FOR ASSESSING BATTERY/CELL CAPACITY; U.S. Patent No. 5,343,380, issued August 30, 1994, entitled METHOD AND APPARATUS FOR SUPPRESSING TIME-VARYING SIGNALS IN BATTERIES UNDERGOING CHARGING OR DISCHARGING; U.S. Patent No. 5,572,136, issued November 5, 1996, entitled ELECTRONIC BATTERY TESTER DEVICE; U.S. Patent No. 5,574,355, issued November 12, 1996, entitled METHOD AND APPARATUS FOR DETECTION AND CONTROL OF THERMAL RUNAWAY IN A BATTERY UNDER CHARGE; U.S. Patent No. 5,585,416, issued December 10, 1996, entitled APPARATUS AND METHOD FOR

STEP-CHARGING BATTERIES TO OPTIMIZE CHARGE ACCEPTANCE; U.S. Patent No. 5,585,728, issued December 17, 1996, entitled ELECTRONIC BATTERY TESTER WITH AUTOMATIC COMPENSATION FOR LOW STATE-OF-CHARGE; U.S. Patent No. 5,589,757, issued December 31, 1996, entitled APPARATUS AND METHOD FOR STEP-CHARGING BATTERIES TO OPTIMIZE CHARGE ACCEPTANCE; U.S. Patent No. 5,592,093, issued January 7, 1997, entitled ELECTRONIC BATTERY TESTING DEVICE LOOSE TERMINAL CONNECTION DETECTION VIA A COMPARISON CIRCUIT; U.S. Patent No. 5,598,098, issued January 28, 1997, entitled ELECTRONIC BATTERY TESTER WITH VERY HIGH NOISE IMMUNITY; U.S. Patent No. 5,656,920, issued August 12, 1997, entitled METHOD FOR OPTIMIZING THE CHARGING LEAD-ACID BATTERIES AND AN INTERACTIVE CHARGER; U.S. Patent No. 5,757,192, issued May 26, 1998, entitled METHOD AND APPARATUS FOR DETECTING A BAD CELL IN A STORAGE BATTERY; U.S. Patent No. 5,821,756, issued October 13, 1998, entitled ELECTRONIC BATTERY TESTER WITH TAILORED COMPENSATION FOR LOW STATE-OF CHARGE; U.S. Patent No. 5,831,435, issued November 3, 1998, entitled BATTERY TESTER FOR JIS STANDARD; U.S. Patent No. 5,914,605, issued June 22, 1999, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 5,945,829, issued August 31, 1999, entitled MIDPOINT BATTERY MONITORING; U.S. Patent No. 6,002,238, issued December 14, 1999, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX IMPEDANCE OF CELLS AND BATTERIES; U.S. Patent No. 6,037,751, issued March 14, 2000, entitled APPARATUS FOR CHARGING BATTERIES; U.S. Patent

No. 6,037,777, issued March 14, 2000, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Patent No. 6,051,976, issued April 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Patent No. 6,081,098, issued June 27, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Patent No. 6,091,245, issued July 18, 2000, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Patent No. 6,104,167, issued August 15, 2000, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Patent No. 6,137,269, issued October 24, 2000, entitled METHOD AND APPARATUS FOR ELECTRONICALLY EVALUATING THE INTERNAL TEMPERATURE OF AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Patent No. 6,163,156, issued December 19, 2000, entitled ELECTRICAL CONNECTION FOR ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,172,483, issued January 9, 2001, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX IMPEDANCE OF CELLS AND BATTERIES; U.S. Patent No. 6,172,505, issued January 9, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,222,369, issued April 24, 2001, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Patent No. 6,225,808, issued May 1, 2001, entitled TEST COUNTER FOR ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,249,124, issued June 19, 2001, entitled ELECTRONIC BATTERY TESTER WITH INTERNAL BATTERY; U.S. Patent No. 6,259,254, issued July 10, 2001, entitled APPARATUS AND METHOD FOR

CARRYING OUT DIAGNOSTIC TESTS ON BATTERIES AND FOR RAPIDLY CHARGING BATTERIES; U.S. Patent No. 6,262,563, issued July 17, 2001, entitled METHOD AND APPARATUS FOR MEASURING COMPLEX ADMITTANCE OF CELLS AND BATTERIES; U.S. Patent No. 6,294,896, issued September 25, 2001; entitled METHOD AND APPARATUS FOR MEASURING COMPLEX SELF-IMMITANCE OF A GENERAL ELECTRICAL ELEMENT; U.S. Patent No. 6,294,897, issued September 25, 2001, entitled METHOD AND APPARATUS FOR ELECTRONICALLY EVALUATING THE INTERNAL TEMPERATURE OF AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Patent No. 6,304,087, issued October 16, 2001, entitled APPARATUS FOR CALIBRATING ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,310,481, issued October 30, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,313,607, issued November 6, 2001, entitled METHOD AND APPARATUS FOR EVALUATING STORED CHARGE IN AN ELECTROCHEMICAL CELL OR BATTERY; U.S. Patent No. 6,313,608, issued November 6, 2001, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Patent No. 6,316,914, issued November 13, 2001, entitled TESTING PARALLEL STRINGS OF STORAGE BATTERIES; U.S. Patent No. 6,323,650, issued November 27, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,329,793, issued December 11, 2001, entitled METHOD AND APPARATUS FOR CHARGING A BATTERY; U.S. Patent No. 6,331,762, issued December 18, 2001, entitled ENERGY MANAGEMENT SYSTEM FOR AUTOMOTIVE VEHICLE; U.S. Patent No. 6,332,113, issued December 18, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Patent

No. 6,351,102, issued February 26, 2002, entitled AUTOMOTIVE BATTERY CHARGING SYSTEM TESTER; U.S. Patent No. 6,359,441, issued March 19, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,363,303, issued March 26, 2002, entitled ALTERNATOR DIAGNOSTIC SYSTEM; U.S. Patent No. 6,392,414, issued May 21, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,417,669, issued July 9, 2002, entitled SUPPRESSING INTERFERENCE IN AC MEASUREMENTS OF CELLS, BATTERIES AND OTHER ELECTRICAL ELEMENTS; U.S. Patent No. 6,424,158, issued July 23, 2002, entitled APPARATUS AND METHOD FOR CARRYING OUT DIAGNOSTIC TESTS ON BATTERIES AND FOR RAPIDLY CHARGING BATTERIES; U.S. Patent No. 6,441,585, issued August 17, 2002, entitled APPARATUS AND METHOD FOR TESTING RECHARGEABLE ENERGY STORAGE BATTERIES; U.S. Patent No. 6,445,158, issued September 3, 2002, entitled VEHICLE ELECTRICAL SYSTEM TESTER WITH ENCODED OUTPUT; U.S. Patent No. 6,456,045, issued September 24, 2002, entitled INTEGRATED CONDUCTANCE AND LOAD TEST BASED ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,466,025, issued October 15, 2002, entitled ALTERNATOR TESTER; U.S. Patent No. 6,466,026, issued October 15, 2002, entitled PROGRAMMABLE CURRENT EXCITER FOR MEASURING AC IMMITTANCE OF CELLS AND BATTERIES; U.S. Patent No. 6,534,993, issued March 18, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,544,078, issued April 8, 2003, entitled BATTERY CLAMP WITH INTEGRATED CURRENT SENSOR; U.S. Patent No. 6,556,019, issued April 29, 2003, entitled ELECTRONIC BATTERY

TESTER; U.S. Patent No. 6,566,883, issued May 20, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Patent No. 6,586,941, issued July 1, 2003, entitled BATTERY TESTER WITH DATABUS; U.S. Patent No. 6,597,150, issued July 22, 2003, entitled METHOD OF DISTRIBUTING JUMP-START BOOSTER PACKS; U.S. Patent No. 6,621,272, issued September 16, 2003, entitled PROGRAMMABLE CURRENT EXCITER FOR MEASURING AC IMMITTANCE OF CELLS AND BATTERIES; U.S. Patent No. 6,623,314, issued September 23, 2003, entitled KELVIN CLAMP FOR ELECTRICALLY COUPLING TO A BATTERY CONTACT; U.S. Patent No. 6,633,165, issued October 14, 2003, entitled IN-VEHICLE BATTERY MONITOR; U.S. Patent No. 6,635,974, issued October 21, 2003, entitled SELF-LEARNING POWER MANAGEMENT SYSTEM AND METHOD; U.S. Serial No. 09/780,146,filed February 9, 2001, entitled STORAGE BATTERY WITH INTEGRAL BATTERY TESTER; U.S. Serial No. 09/756,638, filed January 8, 2001, entitled METHOD AND APPARATUS FOR DETERMINING BATTERY PROPERTIES FROM COMPLEX IMPEDANCE/ADMITTANCE; U.S. Serial No. 09/862,783, filed May 21, 2001, entitled METHOD AND APPARATUS FOR TESTING CELLS AND BATTERIES EMBEDDED IN SERIES/PARALLEL SYSTEMS; U.S. Patent No. 6,469,511, issued November 22, 2002, entitled BATTERY CLAMP WITH EMBEDDED ENVIRONMENT SENSOR; U.S. Serial No. 09/880,473, filed June 13, 2001; entitled BATTERY TEST MODULE; U.S. Patent No. 6,495,990, issued December 17, 2002, entitled METHOD AND APPARATUS FOR EVALUATING STORED CHARGE IN AN ELECTROCHEMICAL CELL OR BATTERY;

U.S. Serial No. 60/348,479, filed October 29, 2001, entitled CONCEPT FOR TESTING HIGH POWER VRLA BATTERIES; U.S. Serial No. 10/046,659, filed October 29, 2001, entitled ENERGY MANAGEMENT SYSTEM FOR AUTOMOTIVE VEHICLE; U.S. Serial No. 09/993,468, filed November 14, 2001, entitled KELVIN CONNECTOR FOR A BATTERY POST; U.S. Serial No. 09/992,350, filed November 26, 2001, entitled ELECTRONIC BATTERY TESTER; U.S. Serial No. 10/042,451, filed January 8, 2002, entitled BATTERY CHARGE CONTROL DEVICE; U.S. Serial No. 10/073,378, filed February 8, 2002, entitled METHOD AND APPARATUS USING A CIRCUIT MODEL TO EVALUATE CELL/BATTERY PARAMETERS; U.S. Serial No. 10/093,853, filed March 7, 2002, entitled ELECTRONIC BATTERY TESTER WITH NETWORK COMMUNICATION; U.S. Serial No. 10/098,741, filed March 14, 2002, entitled METHOD AND APPARATUS FOR AUDITING A BATTERY TEST; U.S. Serial No. 10/112,114, filed March 28, 2002, entitled BOOSTER PACK WITH STORAGE CAPACITOR; U.S. Serial No. 10/109,734, filed March 28, 2002, entitled APPARATUS AND METHOD FOR COUNTERACTING SELF DISCHARGE IN A STORAGE BATTERY; U.S. Serial No. 10/112,105, filed March 28, 2002, entitled CHARGE CONTROL SYSTEM FOR A VEHICLE BATTERY; U.S. Serial No. 10/112,998, filed March 29, 2002, entitled BATTERY TESTER WITH BATTERY REPLACEMENT OUTPUT; U.S. Serial No. 10/119,297, filed April 9, 2002, entitled METHOD AND APPARATUS FOR TESTING CELLS AND BATTERIES EMBEDDED IN SERIES/PARALLEL SYSTEMS; U.S. Serial No. 60/387,046, filed June 7, 2002, entitled METHOD AND APPARATUS FOR

INCREASING THE LIFE OF A STORAGE BATTERY; U.S. Serial No. 10/177,635, filed June 21, 2002, entitled BATTERY CHARGER WITH BOOSTER PACK; U.S. Serial No. 10/200,041, filed July 19, 2002, entitled AUTOMOTIVE VEHICLE ELECTRICAL SYSTEM DIAGNOSTIC DEVICE; U.S. Serial No. 10/217,913, filed August 13, 2002, entitled, BATTERY TEST MODULE; U.S. Serial No. 10/246,439, filed September 18, 2002, entitled BATTERY TESTER UPGRADE USING SOFTWARE KEY; U.S. Serial No. 10/263,473, filed October 2, 2002, entitled ELECTRONIC BATTERY TESTER WITH RELATIVE TEST OUTPUT; U.S. Serial No. 10/271,342, filed October 15, 2002, entitled IN-VEHICLE BATTERY MONITOR; U.S. Serial No. 10/310,515, filed December 5, 2002, entitled BATTERY TEST MODULE; U.S. Serial No. 10/310,490, filed December 5, 2002, entitled ELECTRONIC BATTERY TESTER; U.S. Serial No. 10/310,385, filed December 5, 2002, entitled BATTERY TEST MODULE; U.S. Serial No. 60/437,255, filed December 31, 2002, entitled REMAINING TIME PREDICTIONS; U.S. Serial No. 60/437,224, filed December 31, 2002, entitled DISCHARGE VOLTAGE PREDICTIONS; U.S. Serial No. 60/437,611, filed January 2, 2003, entitled REMAINING TIME PREDICTIONS; U.S. Serial No. 10/349,053, filed January 22, 2003, entitled APPARATUS AND METHOD FOR PROTECTING A BATTERY FROM OVERDISCHARGE; U.S. Serial No. 10/388,855, filed March 14, 2003, entitled ELECTRONIC BATTERY TESTER WITH BATTERY FAILURE TEMPERATURE DETERMINATION; U.S. Serial No. 10/396,550, filed March 25, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Serial No. 60/467,872,

filed May 5, 2003, entitled METHOD FOR DETERMINING BATTERY STATE OF CHARGE; U.S. Serial No. 60/477,082, filed June 9, 2003, entitled ALTERNATOR TESTER; U.S. Serial No. 10/460,749, filed June 12, 2003, entitled MODULAR BATTERY TESTER FOR SCAN TOOL; U.S. Serial No. 10/462,323, filed June 16, 2003, entitled ELECTRONIC BATTERY TESTER HAVING A USER INTERFACE TO CONFIGURE A PRINTER; U.S. Serial No. 10/601,608, filed June 23, 2003, entitled CABLE FOR ELECTRONIC BATTERY TESTER; U.S. Serial No. 10/601,432, filed June 23, 2003, entitled BATTERY TESTER CABLE WITH MEMORY; U.S. Serial No. 60/490,153, filed July 25, 2003, entitled SHUNT CONNECTION TO A PCB FOR AN ENERGY MANAGEMENT SYSTEM EMPLOYED IN AN AUTOMOTIVE VEHICLE; U.S. Serial No. 10/653,342, filed September 2, 2003, entitled ELECTRONIC BATTERY TESTER CONFIGURED TO PREDICT A LOAD TEST RESULT; U.S. Serial No. 10/654,098, filed September 3, 2003, entitled BATTERY TEST OUTPUTS ADJUSTED BASED UPON BATTERY TEMPERATURE AND THE STATE OF DISCHARGE OF THE BATTERY; U.S. Serial No. 10/656,526, filed September 5, 2003, entitled METHOD AND APPARATUS FOR MEASURING A PARAMETER OF A VEHICLE ELECTRICAL SYSTEM; U.S. Serial No. 10/656,538, filed September 5, 2003, entitled ALTERNATOR TESTER WITH ENCODED OUTPUT; U.S. Serial No. 10/675,933, filed September 30, 2003, entitled QUERY BASED ELECTRONIC BATTERY TESTER; U.S. Serial No. 10/678,629, filed October 3, 2003, entitled ELECTRONIC BATTERY TESTER/CHARGER WITH INTEGRATED BATTERY CELL

TEMPERATURE MEASUREMENT DEVICE; U.S. Serial No. 10/441,271, filed May 19, 2003, entitled ELECTRONIC BATTERY TESTER; U.S. Serial No. 09/653,963, filed September 1, 2000, entitled SYSTEM AND METHOD FOR CONTROLLING POWER GENERATION AND STORAGE; U.S. Serial No. 09/654,217, filed September 1, 2000, entitled SYSTEM AND METHOD FOR PROVIDING STEP-DOWN POWER CONVERSION USING INTELLIGENT SWITCH; U.S. Patent No. 6,465,908, issued October 15, 2002, entitled INTELLIGENT POWER MANAGEMENT SYSTEM; U.S. Patent No. 6,497,209, issued December 24, 2002, entitled SYSTEM AND METHOD FOR PROTECTING A CRANKING SUBSYSTEM; U.S. Patent No. 6,437,957, issued August 20, 2002, entitled SYSTEM AND METHOD FOR PROVIDING SURGE, SHORT, AND REVERSE POLARITY CONNECTION PROTECTION; U.S. Patent No. 6,377,031, issued April 23, 2002, entitled INTELLIGENT SWITCH FOR POWER MANAGEMENT; U.S. Serial No. 10/174,110, filed June 18, 2002, entitled DAYTIME RUNNING LIGHT CONTROL USING AN INTELLIGENT POWER MANAGEMENT SYSTEM; U.S. Serial No. 60/488,775, filed July 21, 2003, entitled ULTRASONICALLY ASSISTED CHARGING; U.S. Serial No. 10/258,441, filed April 9, 2003, entitled CURRENT MEASURING CIRCUIT SUITED FOR BATTERIES; U.S. Patent No. 6,507,196, issued January 14, 2003; entitled BATTERY HAVING DISCHARGE STATE INDICATION; U.S. Patent No. 5,871,858, issued February 16, 1999, entitled ANTI-THEFT BATTERY; U.S. Serial No. 10/705,020, filed November 11, 2003, entitled APPARATUS AND METHOD FOR SIMULATING A BATTERY TESTER

WITH A FIXED RESISTANCE LOAD; U.S. Serial No. 10/280,186, filed October 25, 2002, entitled BATTERY TESTER CONFIGURED TO RECEIVE A REMOVABLE DIGITAL MODULE; and U.S. Serial No. 10/681,666, filed October 8, 2003, entitled ELECTRONIC BATTERY TESTER WITH PROBE LIGHT; which are incorporated herein in their entirety.

Electronic battery testers and chargers are often used in harsh environments and are expected to function properly over an extended period of time. One source of failure in electronic battery testers and chargers are the clamps which are used to electrically couple the battery tester to terminals of storage batteries.

SUMMARY OF THE INVENTION

A method and apparatus for coupling a battery charger and/or a battery tester to a battery is provided. In one aspect of the present invention, a clamp can be selectively removed from a cable. This allows replacement of the clamp as desired. The cable can be fixedly or removably coupled to the battery tester or charger.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a clamp in accordance with the prior art.

FIG. 2-1 is a perspective view of a replaceable clamp electrically coupled with a cable in accordance with an embodiment of the present invention.

FIG. 2-2 is a perspective view of a replaceable clamp partially cutaway and electrically coupled with a cable in accordance with an embodiment of the present invention.

FIG. 2-3 is a perspective view of a replaceable clamp disconnected from a cable in accordance with an embodiment of the present invention.

FIG. 3 is a simplified block diagram of a battery tester with which the present invention is useful.

FIG. 4 is a simplified block diagram of a battery charger with which the present invention is useful.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the discussion below, the term "battery contact" is used to define a portion of the battery onto which the replaceable clamp of the present invention can be applied. The actual contact is an electrical contact and can be placed some distance from the battery.

FIG. 1 is a side view of a Kelvin clamp 100 in accordance with the prior art. Clamp 100 includes first elongate clamp member 102 having a first jaw 106 and first hand grip 110 separated by a first coupling (hidden from view). Clamp 100 also includes second elongate clamp member 104 having a second jaw 108 and a second hand grip 112 separated by second coupling 116. Second elongate clamp member 104 is

pivotally joined with first elongate clamp member 102 by second coupling 116 and the first coupling.

First elongate clamp member 102 is coupled to cable 124. Cable 124 includes a first electrical conductor (hidden from view) and a second electrical conductor (hidden from view), which are electrically isolated from each other. The first electrical conductor is electrically coupled to first jaw 106 and conductive piece 136, which grips a battery contact. Rivet 111 couples conductive piece 136 to jaw 106 and is insulated from first elongate clamp member 102 by an insulator 115. The second electrical conductor can be electrically coupled to second jaw 108 or electrically coupled to first jaw 108. The first electrical conductor and the second electrical conductor provide Kelvin connections to the battery contacts.

Clamp 100 is used in harsh environments to test and charge lead acid or other batteries. Gases will attack metal and corrode terminals on the clamp causing clamp 100 to easily wear out. The present invention provides a replaceable clamp for quickly and efficiently replacing a corroded clamp with a non-corroded clamp in the field by a user.

FIGS. 2-1 through 2-3 are perspective views of replaceable clamp 200 in accordance with an embodiment of the present invention. Clamp 200 is designed to electrically connect cable 224 from a battery tester and/or charger (not shown) to a

battery contact. Clamp 200 can either connect to a negative or positive battery contact. FIGS. 2-1 through 2-3 illustrate this electrical connection as a Kelvin connection, a sensor lead connection, and a connection capable of carrying a high current for charging a battery. Other types of connections that electrically connect the battery tester or charger to the battery contacts are within the scope of the present invention.

FIG. 2-1 illustrates clamp 200 electrically connected with cable 224 and configured in a closed position. Clamp 200 includes a first elongate clamp member 202 which has first jaw end 206 and first hand grip end 210 separated by first pivot coupling 214. Replaceable clamp 200 also includes second elongate clamp member 204 which has second jaw end 208 and second hand grip end 212 separated by a second pivot coupling (hidden from view). Second elongate clamp member 204 is pivotally joined to first elongate clamp member 202 by first pivot coupling 214 and the second pivot coupling. Pivotally joining first elongate clamp member 202 to second elongate clamp member 204 causes first jaw end 206 to be aligned with second jaw end 208. First jaw end 206 and second jaw end 208 are in a closed position.

FIG. 2-2 illustrates clamp 200 partially cutaway and electrically connected with cable 224. Clamp 200 includes a spring 215 coupled to first elongate clamp member 202 and second elongate clamp member 204. The

spring is configured to urge first jaw end 206 and second jaw end 208 together in a closed position. First elongate clamp member 202 also includes electrically conductive piece 236, which is mechanically coupled to second jaw end 208 by rivet 234. An insulator 217 isolates rivet 234 from conductive piece 236.

Referring to both FIGS. 2-1 and 2-2, cable 224 includes a main electrical connector 221, a first electrical connector 229 and a second electrical connector 235. Those skilled in the art will recognized that multiple electrical connectors can be housed in cable 224 to electrically connect to a clamp, such as clamp 200.

The main electrical connector 221 is capable of carrying a high current such that the high current can charge a battery. Terminal 218 is electrically coupled to the main electrical connector. Terminal 218 includes terminal hole 220 which aligns with first hole (not shown in FIGS. 2-1 or 2-2) of first hand grip 210. Removable fastener 222 (shown fastened in FIG. 2-1 and shown unfastened in FIG. 2-2) couples terminal 218 to first hand grip 210 through the first hole and terminal hole 220 such that fastener 222 can disconnect clamp 200 from cable 224.

First electrical conductor 229 includes first portion 230 and second portion 232. Second electrical conductor 235 includes first portion 231 and second portion 233. First portion 230 of first electrical

conductor 229 is electrically coupled to conductive piece 236 at one end and coupled to first electrical plug 226 at the other end. First portion 231 of second electrical conductor 235 is electrically coupled to second jaw 208 through rivet 234 at one end and coupled to first electrical plug 226 at the other end. Second portions 232 and 233 are coupled to cable 224 at one end and coupled to second electrical plug 228 at the other end. First electrical plug 226 is removably electrically connected with second electrical plug 228.

In one embodiment of the present invention, first electrical conductor 229 and second electrical conductor 235 together provide a Kelvin connection capable of injecting a forcing function into a battery as well as measuring a voltage across the battery. In another embodiment of the present invention, first electrical conductor 229 includes two electrically isolated contacts which provide a Kelvin connection and second electrical conductor 235 provides a sensor lead that is capable of sensing a physical property of the battery, such as temperature as discussed in FIG. 3. Those skilled in the art will recognize that electrical conductors 229 and 235 can be electrically coupled anywhere along first and second elongate clamp members 202 and 204 as long as at least one of first and second electrical conductors 229 and 235 electrically couple with a

battery contact to provide a Kelvin connection or a sensor lead.

FIG. 2-3 illustrates replaceable clamp 200 with removable fastener (not shown in FIG. 2-3) removed from terminal 218 and first electrical plug 226 electrically disconnected from second electrical plug 228. FIG. 2-3 also illustrates first hole 217 formed in first hand grip 210 such that terminal hole 220 will align with first hole 217 when the fastener is connecting cable 224 to clamp 200. Electrical plugs 226 and 228 and the removable fastener electrically disconnect clamp 200 from cable 224. Thus, clamp 200 can be entirely replaced with a second clamp having a similar configuration. In general, first jaw 206, second jaw 208 and the electrically conductive piece (not shown in FIG. 2-3) can be formed of an electrically conductive material such as copper. In addition, insulating grips can be provided on first and second hand grips (210, 212) for user protection.

FIG. 3 is a simplified block diagram of an example electronic battery tester circuitry 300 with which the present invention is useful. The present invention is not restricted in application to the battery test circuitry 300 of FIG. 3. Other types of battery test circuitry are within the scope of the present invention. Illustrated in FIG. 3 is a four point (or Kelvin connection) technique used to couple system 300 to battery 302. Connections 308 and 310 are used to couple to battery contacts 304 and 306,

respectively, of battery 302. Connection 308 includes two individual connections 308A and 308B. Similarly, connection 310 includes two individual connections 310A and 310B. Clamps 200 of the present invention grasp battery contacts 304 and 306 and couple them to electrical connections 308 and 310.

Circuitry 300 includes a current source 312 and a differential amplifier 314. Current source 312 is coupled to connections 308B and 310B of connections 308 and 310, respectively. Differential amplifier 314 is coupled to connection 308A and connections 310A of connections 308 and 310, respectively. An output from differential amplifier 314 is provided to analog to digital converter 318 which itself provides a digitized output to microprocessor 320. Microprocessor 320 is connected to a system clock 322, a memory 324 and analog to digital converter 318. Microprocessor 320 is also capable of receiving an input from an input device 326 and providing an output of output device 328. The input can be, for example, a rating for the battery 302. Input device can comprise any of the following multiple types of input devices. The result of a battery test, either qualitative or quantitative, can be an output device 328. Device 328 can be a display or other output. The invention can operate with any technique for determining a voltage across battery 302 and a current through battery 302 and is not limited to the specific techniques set forth herein. The forcing

function source or current source 312 can provide any signal having a time varying component, including a stepped pulse or a periodic signal, having any shape, applied to battery 302. The current source can be an active source in which the current source signal is injected into battery 302, or can be a passive source, such as a load, which is switched on under the control of microprocessor 320.

In operation, microprocessor 320 determines a dynamic parameter, such as dynamic conductance, of battery 302 as a function of sensed voltage and current. The change in these sensed values is used to determine the dynamic parameter. A temperature sensor 330 can be thermally coupled to battery 302 and used to compensate battery measurements. Temperature readings can be stored in memory 324 for later retrieval.

FIG. 4 is a simplified block diagram of a battery charging system 400 with which the present invention is useful. The present invention is not restricted in application to the battery charging system 400 of FIG. 4. Other types of battery charging systems are within the scope of the present invention. System 400 is shown coupled to battery 402. System 400 includes battery charging and testing circuitry 404 and microprocessor 406. System 400 couples to battery contacts 408 and 410 through Kelvin electrical connections 412 and 414 respectively. Electrical connection 412 includes a

first connection 412A and second connection 412B and connection 414 includes a first connection 414A and a second connection 414B. Clamps 200 of the present invention provide coupling between battery contacts 408 and 410 and electrical connections 412 and 414. Battery charger 400 operates in a manner similar to the battery charger set forth in U.S. Patent No. 6,104,167, issued August 15, 2000, and entitled "METHOD AND APPARATUS FOR CHARGING A BATTERY", which is incorporated herein by reference.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.